Appendix 3-C (Risk Chapter)
Supplementary Environmental Air Release Information

Mass Balance Calculations

The mass balance calculations for determining environmental releases from the ink formulations were conducted as follows for each formulation:

- Determine which components will volatilize (i.e., have vapor pressure greater than or equal to 0.001 mmHg at 25°C).
- Components that do not volatilize will remain on the substrate and are not expected to result in releases to the environment.
- Multiply volatile component masses by 99.9% to represent the amount of the compounds that volatilize.
- Multiply the mass of the component that volatilizes by 30% to determine the mass of the component that is released as fugitive emissions.
- Multiply mass of the component that volatilizes by 70% to determine the mass of the component that is captured by the exhaust system.
- For solvent-based formulations, multiply the mass of the component captured by the exhaust system by 5% to determine the mass of the component that is released as stack emissions (the catalytic oxidizer has a 95% destruction efficiency). For UV-cured and water-based formulations, the mass of the component that is released as stack emissions is equal to the mass of the component captured by the exhaust system (there are no controls on the UV-cured or water-based systems).
- Convert the release amounts from pounds per 7.5 hours to grams per second.

Sample Calculation of Environmental Releases

Following the methodology outlined above, the fugitive and stack releases for each component of the ink formulations were calculated. Applying the above methodology to the example data presented in Table 3.8 resulted in the data presented in Table D.1 below.

- The non-volatile components of the mixture are pigment, nitrocellulose, and resin; their vapor pressures are less than 0.001 mmHg at 25°C.
- From Table 3.8, the total mass of ink mixture consumed per 7.5 hour run is 95.815 pounds.

- The mass of ethanol consumed per 7.5 hour run is the total mass of ink mixture consumed (95.815 pounds) times the weight percent of ethanol in the ink mixture (19.8%) or 18.971 pounds. Of this amount, 99.9%, or 18.952 pounds, volatilizes per 7.5 hour run. The total mass of the five volatile components consumed per 7.5 hour run is 77.131 pounds. Applying the same methodology, the total mass of ink mixture that volatilizes per 7.5 hour run (99.9% of the amount consumed) is 77.054 pounds.

  95.815 lbs. ink mixture consumed (19.8%) = 18.971 lbs. ethanol consumed
  18.971 lbs. ethanol consumed (99.9%) = 18.952 lbs. ethanol volatilized

Table 3-C Example Data for a Flexographic Printing Solvent-Based Formulation*

Chemical Component	Weight Percent	Vapor Pressure (mmHg at 25°C)	Fugitive Air Release (grams/sec)	Stack Air Release (grams/sec)
Ethanol	19.8%	59.03	0.096	0.011
Pigment	14.6%	$<10^{-6}$	0	0
Propyl acetate	10.0%	33.7	0.048	0.0056
Propanol	43.3%	21	0.21	0.024
Nitrocellulose	2.7%	$<10^{-6}$	0	0
Resin	2.2%	$2x10^{-4}$	0	0
Glycol ether	1.3%	10.2	0.0063	0.00073
Extender compound	6.1%	0.001	0.029	0.0034

*The solvent-based formulation presented above is a fictional formulation.

In this example:

- The mass of ethanol released as fugitive emissions (30% of the total amount released) per 7.5 hour run is 5.686 pounds, which converts to 0.0957 grams of ethanol emitted per second. Similarly, the total mass of the five volatile components released as fugitive emissions per 7.5 hour run is 23.116 pounds, which converts to 0.389 grams of volatiles emitted per second.

  18.952 lbs. ethanol volatilized (30%) = 5.686 lbs. fugitive ethanol emissions
  5.686 lbs./7.5hrs. (1000g/kg)(1kg/2.2lbs.)(1hr/3600sec)=0.0957 g/sec

- The mass of ethanol captured by the exhaust system per 7.5 hour run is the amount of ethanol that volatilizes (18.952 pounds) times the capture efficiency (70%), or 13.266 pounds. The corresponding total mass of the five volatile components captured by the exhaust system per 7.5 hour run is 77.054 pounds times the capture efficiency of 70%, or 53.938 pounds.

  18.952 lbs. ethanol volatilized (70%) = 13.266 lbs. ethanol captured

- The mass of ethanol destroyed by the air control system is the amount of ethanol captured by the exhaust system (13.266 pounds) times the destruction efficiency (95%), or 12.603 pounds. The total mass of the five volatile components destroyed by the air control system is 53.938 pounds times the destruction efficiency of 95%, or 51.241 pounds.

  13.266 lbs. ethanol captured (95%) = 12.603 lbs. ethanol destroyed

- The mass of ethanol released as stack emissions per 7.5 hour run from the exhaust system is 5% of the mass of ethanol captured (13.266 pounds), or 0.663 pounds, which converts to 0.011 grams of ethanol emitted per second. The total mass of ink mixture that is released as stack emissions per 7.5 hour run is 2.697 pounds, or 0.045 grams of ink mixture emitted per second.

  13.266 lbs. ethanol captured (5%) = 0.663 lbs. ethanol stack emissions

Appendix 3-D (Risk Chapter)
Environmental Air Release Data

Chemical category *(additives in italics)*	Blue			Green			White			Cyan			Magenta		
	Air releases per press (g/sec)														
	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases
Solvent-based Ink #S1 – Site 9B															
Alcohols	0.031	0.009	0.001	0.022	0.007	0.001	0.082	0.025	0.003	0.011	0.003	0.000	0.014	0.004	0.000
Alcohols	0.194	0.058	0.007	0.165	0.049	0.006	1.069	0.321	0.037				0.073	0.022	0.003
Alkyl acetates	0.103	0.031	0.004	0.118	0.035	0.004	0.219	0.066	0.008				0.063	0.019	0.002
Alkyl acetates	0.004	0.001	0.000				0.082	0.025	0.003						
Propylene glycol ethers				0.022	0.007	0.001				0.026	0.008	0.001	0.021	0.006	0.001
Alkyl acetates				0.022	0.007	0.001				0.042	0.013	0.001	0.010	0.003	0.000
Alcohols				0.329	0.099	0.011				0.384	0.115	0.013	0.353	0.106	0.012
Hydrocarbons - low molecular weight							0.945	0.284	0.033						
Additive: Propanol	*0.106*	*0.032*	*0.004*				*0.053*	*0.016*	*0.002*						
Additive: Propyl acetate										*0.025*	*0.007*	*0.001*			
Additive: Trade secret													*ND*[b]	*ND*	*ND*
Additive: Propylene glycol ether													*0.018*	*0.005*	*0.001*
Solvent-based Ink #S2 – Site 5															
Alcohols	0.574	0.172	0.020	0.550	0.165	0.019	1.112	0.334	0.039	0.768	0.230	0.027	0.519	0.156	0.018
Alkyl acetates	0.132	0.039	0.005	0.117	0.035	0.004	0.053	0.016	0.002	0.217	0.065	0.008	0.134	0.040	0.005
Hydrocarbons - low molecular weight	0.119	0.036	0.004	0.176	0.053	0.006	0.584	0.175	0.020	0.152	0.046	0.005	0.266	0.080	0.009
Alcohols	0.071	0.021	0.002	0.081	0.024	0.003	0.120	0.036	0.004	0.106	0.032	0.004	0.086	0.026	0.003
Hydrocarbons - low molecular weight	0.006	0.002	0.000	0.005	0.001	0.000	0.025	0.007	0.001	0.010	0.003	0.000	0.009	0.003	0.000
Alcohols	0.073	0.022	0.002	0.084	0.025	0.003				0.096	0.029	0.003	0.146	0.044	0.005

Chemical category *(additives in italics)*	Blue			Green			White			Cyan			Magenta		
	Air releases per press (g/sec)														
	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases
Solvent-based Ink #S2 – Site 7															
Alcohols	0.243	0.073	0.008	0.239	0.072	0.008	0.461	0.138	0.016	0.206	0.062	0.007	0.252	0.076	0.009
Alkyl acetates	0.218	0.065	0.008	0.203	0.061	0.007	0.263	0.079	0.009	0.191	0.057	0.007	0.223	0.067	0.008
Hydrocarbons - low molecular weight	0.092	0.027	0.003	0.100	0.030	0.003	0.378	0.113	0.013	0.062	0.019	0.002	0.166	0.050	0.006
Alcohols	0.055	0.016	0.002	0.046	0.014	0.002	0.078	0.023	0.003	0.043	0.013	0.001	0.091	0.027	0.003
Hydrocarbons - low molecular weight	0.005	0.001	0.000	0.002	0.001	0.000	0.016	0.005	0.001	0.004	0.001	0.000	0.006	0.002	0.000
Alcohols	0.609	0.183	0.021	0.627	0.188	0.022				0.497	0.149	0.017	0.644	0.193	0.022
Additive: Propanol							*1.029*	*0.309*	*0.036*						
Solvent-based Ink #S2 – Site 10															
Alcohols	0.197	0.059	0.007	0.244	0.073	0.008	0.407	0.122	0.014	0.199	0.060	0.007	0.208	0.062	0.007
Alkyl acetates	0.126	0.038	0.004	0.125	0.038	0.004	0.142	0.043	0.005	0.154	0.046	0.005	0.062	0.019	0.002
Hydrocarbons - low molecular weight	0.074	0.022	0.003	0.102	0.030	0.004	0.334	0.100	0.012	0.060	0.018	0.002	0.137	0.041	0.005
Alcohols	0.045	0.013	0.002	0.047	0.014	0.002	0.069	0.021	0.002	0.042	0.013	0.001	0.075	0.023	0.003
Hydrocarbons - low molecular weight	0.004	0.001	0.000	0.003	0.001	0.000	0.014	0.004	0.000	0.004	0.001	0.000	0.005	0.001	0.000
Alcohols	0.603	0.181	0.021	0.659	0.198	0.023				0.345	0.104	0.012	0.792	0.238	0.028
Additive: Propanol							*1.220*	*0.366*	*0.043*						
Additive: Propylene glycol monomethyl ether										*0.315*	*0.095*	*0.011*	*0.069*	*0.021*	*0.002*
Additive: 2-Methoxy-1-propanol										*0.006*	*0.002*	*0.000*	*0.001*	*0.000*	*0.000*

Chemical category *(additives in italics)*	Blue			Green			White			Cyan			Magenta		
	Air releases per press (g/sec)														
	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases
Water-based Ink #W1 – Site 4															
Amides or nitrogenous compounds	0.013	0.004	0.009	0.011	0.003	0.008	0.082	0.024	0.057	0.003	0.001	0.002	0.003	0.001	0.002
Alcohols	0.100	0.030	0.070	0.057	0.017	0.040	0.164	0.049	0.114	0.012	0.004	0.009			
Ethylene glycol ethers	0.032	0.009	0.022	0.019	0.008	0.013				0.022	0.007	0.016	0.023	0.007	0.016
Alcohols	0.005	0.001	0.004	0.003	0.001	0.002									
Hydrocarbons - high molecular weight	0.019	0.006	0.013	0.010	0.003	0.007									
Water-based Ink #W2 – Site 1															
Amides or nitrogenous compounds	0.002	0.000	0.001	0.003	0.001	0.002	0.092	0.028	0.065				0.002	0.001	0.002
Hydrocarbons - high molecular weight	0.001	0.000	0.001	0.002	0.001	0.001	0.015	0.005	0.011				0.001	0.000	0.000
Hydrocarbons - low molecular weight	0.001	0.000	0.000	0.001	0.000	0.001									
Alcohols							0.038	0.011	0.027						
Ethylene glycol ethers							0.038	0.011	0.027						
Additive: Isobutanol	*0.001*	*0.000*	*0.000*							*0.001*	*0.000*	*0.001*	*0.001*	*0.000*	*0.001*
Additive: Ethyl carbitol	*0.001*	*0.000*	*0.000*							*0.001*	*0.000*	*0.001*	*0.001*	*0.000*	*0.001*
Additive: Propanol	*0.043*	*0.013*	*0.030*				*0.009*	*0.003*	*0.007*						
Additive: Ammonia										*0.002*	*0.001*	*0.001*			

Chemical category *(additives in italics)*	Blue			Green			White			Cyan			Magenta		
	Air releases per press (g/sec)														
	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases
Water-based Ink #W3 – Site 2															
Amides or nitrogenous compounds	0.021	0.006	0.015	0.028	0.008	0.020	0.046	0.014	0.032	0.016	0.005	0.011	0.017	0.005	0.012
Propylene glycol ethers										0.002	0.001	0.002	0.003	0.001	0.002
Alcohols				0.013	0.004	0.009									
Ethylene glycol ethers				0.006	0.002	0.004									
Alcohols							0.013	0.004	0.009						
Additive: Ammonia	*0.002*	*0.000*	*0.001*	*0.001*	*0.000*	*0.001*	*0.002*	*0.000*	*0.001*	*0.002*	*0.001*	*0.001*	*0.002*	*0.001*	*0.001*
Additive: Propanol	*0.019*	*0.006*	*0.013*	*0.010*	*0.003*	*0.007*	*0.039*	*0.012*	*0.027*						
Additive: Other components	*ND*	*ND*	*ND*												
Water-based Ink #W3 – Site 3															
Amides or nitrogenous compounds	0.015	0.004	0.010	0.028	0.008	0.019	0.065	0.020	0.046	0.008	0.002	0.005	0.005	0.001	0.003
Propylene glycol ethers										0.001	0.000	0.009	0.001	0.000	0.001
Alcohols				0.012	0.004	0.009									
Ethylene glycol ethers				0.006	0.002	0.004									
Alcohols							0.018	0.005	0.013						
Additive: Ammonia	*0.012*	*0.004*	*0.009*				*0.020*	*0.006*	*0.014*	*0.002*	*0.001*	*0.002*	*0.002*	*0.001*	*0.001*
Additive: Propanol	*0.033*	*0.010*	*0.023*				*0.147*	*0.044*	*0.103*						
Additive: Extender							*ND*	*ND*	*ND*						
Additive: 2-Butoxyethanol													*0.001*	*0.000*	*0.001*

Chemical category *(additives in italics)*	Blue			Green			White			Cyan			Magenta		
	Air releases per press (g/sec)														
	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases
Water-based Ink #W4 – Site 9A															
Alcohols	0.011	0.003	0.008	0.005	0.001	0.004	0.050	0.015	0.035	0.017	0.005	0.012	0.007	0.002	0.005
Amides or nitrogenous compounds	0.001	0.000	0.001	0.001	0.000	0.001	0.012	0.004	0.009	0.002	0.001	0.001	0.002	0.001	0.002
Hydrocarbons - high molecular weight	0.001	0.000	0.001	0.001	0.000	0.001	0.012	0.004	0.009	0.001	0.000	0.009	0.001	0.000	0.001
Amides or nitrogenous compounds	0.001	0.000	0.001	0.005	0.002	0.004				0.001	0.000	0.001	0.007	0.002	0.005
Alcohols				0.017	0.005	0.012	0.050	0.015	0.035				0.010	0.003	0.007
Propylene glycol ethers	0.011	0.003	0.008												
Propylene glycol ethers	0.011	0.003	0.008							0.017	0.005	0.012			
Amides or nitrogenous compounds				0.001	0.000	0.001	0.012	0.004	0.009						
Alcohols										0.005	0.001	0.003			
Additive: Ammonia	*0.002*	*0.000*	*0.001*	*0.001*	*0.000*	*0.001*				*0.002*	*0.000*	*0.001*	*0.001*	*0.000*	*0.000*
Additive: Propanol	*0.009*	*0.003*	*0.007*							*0.010*	*0.003*	*0.007*			
Additive: Ethyl carbitol										*ND*	*ND*	*ND*			
Additive: Petroleum distillate										*ND*	*ND*	*ND*			
UV-cured Ink #U1 – Site 11															
Amides or nitrogenous compounds	0.003	0.001	0.002	0.004	0.001	0.002	0.020	0.006	0.014	0.001	0.000	0.001	0.001	0.000	0.001
Aromatic esters	0.016	0.005	0.011	0.017	0.005	0.012	0.096	0.029	0.067	0.006	0.002	0.004	0.006	0.002	0.004
Additive: 1,6-Hexanediol diacrylate				*0.010*	*0.003*	*0.007*									
UV-cured Ink #U2 – Site 6															
Acrylated polyols	0.059	0.018	0.041	0.050	0.015	0.034	0.437	0.131	0.306	0.019	0.006	0.013	0.031	0.009	0.021
Acrylated polyols	0.042	0.013	0.029	0.014	0.004	0.010	0.177	0.053	0.124	0.021	0.006	0.015	0.024	0.007	0.017
Aromatic ketones	0.014	0.004	0.010	0.007	0.002	0.005	0.049	0.015	0.034	0.006	0.002	0.004	0.009	0.003	0.006

Chemical category *(additives in italics)*	Blue			Green			White			Cyan			Magenta		
	Air releases per press (g/sec)														
	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases	Total amount volati-lized	Amount of fugitive releases	Amount of stack releases
UV-cured Ink #U3 – Site 8															
Aromatic esters	0.006	0.002	0.005	0.006	0.002	0.004	0.057	0.017	0.040	0.005	0.001	0.003	0.004	0.001	0.003
Amides or nitrogeneous compounds	0.001	0.000	0.001	0.001	0.000	0.001	0.012	0.004	0.009	0.001	0.000	0.001	0.001	0.000	0.001
Acrylated polyols	0.028	0.008	0.020	0.026	0.008	0.019				0.020	0.006	0.014	0.017	0.005	0.012

[a] Shaded areas indicate where data are not applicable (i.e., the chemical category was not found in the particular color and formulation). If a chemical was found in a formulation, but resulted in zero air releases, then the chemical category was not included in the table for that formulation.
[b] No data or information available.